http://dx.doi.org/10.18778/1429-3730.48.02

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DETERMINANTS OF THE REGIONAL INNOVATION SYSTEM – AN ANALYSIS BASED ON THE CENTRAL FEDERAL DISTRICT OF RUSSIA

DETERMINANTY REGIONALNEGO SYSTEMU INNOWACJI – ANALIZA NA PRZYKŁADZIE CENTRALNEGO FEDERALNEGO DYSTRYKTU ROSJI

Streszczenie

W artykule podjęta jest próba identyfikacji determinantów regionalnego systemu innowacji oraz analizy ich wpływu na wolumen innowacyjnych dóbr i usług na podstawie analizy ekonometrycznej dla lat 2005–2015 na przykładzie gospodarek regionalnych Centralnego Federalnego Dystryktu Rosji. Analizy ekonometryczne danych przekrojowych pokazują, że wpływ regionalnego potencjału innowacyjnego na wolumen innowacyjnych dóbr i usług stał się bardziej zauważalny od 2011 roku. Do regionów z gospodarką zorientowaną na innowacje należy zaliczyć: Lipetsk, Kalugę i Yaroslavl.

Słowa kluczowe: działalność innowacyjna, regionalny system innowacji, determinanty innowacji, analiza korelacyjna, analiza regresji

Klasyfikacja JEL: C15, O31, P51

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Introduction

In the history of the world economy, the 21st century is designated as the age of science and high technology. The investigation of this sphere in the leading countries of the world is marked by searching for proper scientific, technical and innovation policies. A key role in the implementation of the innovation economy and increasing its efficiency is assigned to regional innovation systems (RIS). Of course, the formation of RIS is a long and complex process.

The purpose of this article is to investigate the relationship between the volume of innovation goods and services and the factors that determine their volume, by taking the Central Federal District (CFD) of the Russian Federation as an example. The prerequisite for the investigation was a theoretical analysis of the innovation system in the literature[1].

In accordance with the goal, the aims of this research are to identify the factors that significantly affect innovation processes; this identification is based on the consideration of statistical functional links in the innovation system and the selection of those determinants that are most liable to economic justification. A number of authors conducted similar studies for the Russian economy as a whole and we treat them as a kind of reference[2].

Definition of the regional innovation system

A regional innovation system can be understood as a national innovation system, with all its identified features and characteristics, but with a smaller geographic dimension. This view of RIS results from the positioning of regions as elements of a nationwide economic system. Taking into account various definitions of the "national innovation system", it is suggested to use the following definition of RIS.

The regional innovation system is a set of actively interacting participants of innovation activity involved in the processes of creation, dissemination and use of new knowledge for the purpose of mastering various kinds of innovations

[1] J.A. Schumpeter, *Theory of Economic Investigation*, 1982, http://bookree.org/reader?file=717618&pg=3 [accessed: 15.03.2017]; B. Twiss, *Management of scientific and technological innovations*, Economics, Moscow 1989.

[2] A.S. Dubinin, *Essence and methods for assessing innovation activity in the region*, "Bulletin of the Novgorod State University" 2011, No. 61; O.S. Moskvina, *Evaluation of the influence of dominant factors on the innovation investigation of the region*, "Bulletin of the UrFU. Series of Economics and Management" 2010, No. 1; A.A. Mirolyubova, I.V. Dvornik, *Econometric analysis of the efficiency of the regional innovation system*, "Audit and Financial Analysis" 2016, No. 4.

on the territory of a certain region and providing the region with a complex socio-economic impact.

The result of innovation activity is the volume of innovative goods and services produced in the course of various economic activities. According to Rosstat's Methodological Explanations, "innovation goods, activities, services are goods, services and activities either new or subjected to various degrees of technological changes during the last three years"[3].

Data and variables

The statistical database comprised initially of 18 statistical indicators for the subjects of the CFD, with the exception of Moscow and the Moscow Region as typologically heterogeneous with the regions under consideration for the period 2005–2015[4]. Then, 11 relative indicators, which are involved in the analysis of innovation processes in the region, were calculated (Table 1). The factor of time was also taken into consideration.

Table 1. Factors affecting the innovation system of the region's economy

No	Factor Conditional	Designation
1	Proportion of investments in fixed assets in Gross Regional Product (GRP), %	X_1
2	Proportion of domestic expenditure on research and investigation (R & I) in GRP, %	X_2
3	The Proportion of ICT costs in GRP, %	X_3
4	Number of personal computers per 100 workers	X_4
5	The proportion of personnel engaged in research in the total number of employed, %	X_5
6	The Proportion of employees with scientific degrees in the number of employed in R&I, %	X_6
7	Proportion of organizations performing research and investigations, %	X_7
8	Innovation activity of organizations, %	X_8
9	Proportion of the region's advanced production technologies in the total number of advanced technologies of the CFD, %	X_9
10	Proportion of costs for technological innovation in GRP, %	X_{10}
11	The Proportion of patents granted in the total number of CFDs' patents, %	X_{11}

Source: own research.

It is obvious that there must be a direct dependence between the indicators chosen by us and the volume of innovation goods and services. That is, the greater the proportion of the number of personnel engaged in research and investiga-

[3] Federal Service of State Statistics, http://www.gks.ru [accessed: 30.03.2017].

[4] Ibidem.

tions in the total number of employees and the higher the proportion of costs for technological innovation in the gross regional product, etc., the greater the volume of innovation goods, services and works.

Statistical analysis

Before building the models, it is expedient to investigate the degree of correlation links between the factors and the volume of innovation goods and services. To estimate the tightness and direction of the connection, a matrix of pair correlations was constructed (Table 2).

As we can see, the degree of positive impact of the analyzed factors is not so great; Correlation coefficients have in many cases negative values, what in itself is absurd. The rang of factors showed that first of all, the investigation of innovation processes in the regions is affected by computerization (the number of personal computers per 100 employees), which is natural. Wide introduction of computers intensifies the conduct of scientific research and the creation of object of intellectual property, especially in the field of IT-technologies. The most able to mobilize their organization's capacity in a timely manner is in the Kaluga, Lipetsk and Yaroslavl regions.

Only in two regions – in the Vladimir and Tula regions – the creation of the volume of innovation goods and services is influenced by those employed with academic degrees.

One of the key drivers of innovation economy is patent activity. However, a fairly close relationship between the volume of innovation goods and services and the proportion of patents granted in the total number can be seen only in the Kaluga and Orel regions. The absence of influence of this factor indicates that most of the patents are not commercialized or not claimed.

The Efficiency of internal costs for research and investigation can be observed in the Lipetsk and Tula regions.

Logically built into the analysis and corresponds to the reality of today's insignificance of the impact of four factors. Among them, investments in fixed assets, the number of organizations and the number of personnel, respectively performing and engaged in research and investigation, and the number of advanced manufacturing technologies used. Organizations and employees performing research and investigation are one of the five elements of the innovation system – the research and investigation sector. If we consider the dynamics of these indicators for 2005–2014, the number of organizations in the Central Federal District has decreased by 31, the number of employees – by 14,800. However, in 2015, in some regions of the Central Federal District, such as Voronezh, Kaluga, Lipetsk, Ryazan, Smolensk, Tambov and Yaroslavl regions, there is an excess of the number of organizations compared to 2005. Therefore, in 2015, the number of employees engaged in research and investigation increased by 1005 people.

Table 2. Results of the correlation analysis of regional innovation systems (based on time series for 2005–2015)

Subject of CFD	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
Belgorod Area	0.39	0.37	0.16	0.19	0.06	–0.08	0.12	0.15	0.09	–0.45	–0.02
Bryansk Area	–0.45	0.23	0.16	–0.03	0.19	0.39	–0.11	–0.42	0.08	–0.37	–0.41
Vladimirskaya Area	–0.48	–0.57	–0.42	0.52	–0.46	0.54	–0.29	0.43	–0.07	0.45	0.49
Voronezhskaya Area	–0.10	–0.38	–0.45	0.12	–0.04	0.46	0.17	0.28	0.03	–0.06	0.09
Ivanovskaya Area	0.49	0.12	0.32	–0.49	–0.30	–0.29	0.05	–0.59	–0.06	0.34	0.47
Kaluga Area	–0.42	0.06	–0.20	–0.60	0.37	0.36	–0.49	0.62	0.71	–0.39	0.76
Kostroma region	0.39	–0.18	–0.02	–0.29	0.13	–0.43	–0.28	0.07	0.31	0.45	0.40
Kursk Area	–0.30	–0.14	–0.16	0.59	0.06	0.17	–0.54	–0.13	–0.30	0.33	–0.15
Lipetsk Area	0.05	0.75	0.57	0.85	0.39	0.26	0.38	0.71	0.20	0.23	–0.34
Orel Region	–0.15	–0.02	0.28	–0.56	0.38	0.48	0.13	0.48	0.14	0.28	0.58
Ryazan Area	0.08	0.09	0.14	0.13	0.21	0.14	0.03	0.04	–0.20	–0.10	–0.25
Smolenskaya Area	–0.02	0.05	–0.01	0.59	–0.45	–0.02	0.17	0.21	–0.38	0.17	–0.56
Tambov Area	0.02	0.41	0.31	0.05	–0.01	0.27	–0.18	0.38	0.04	0.28	0.11
Tverskaya Area	0.51	–0.33	0.09	0.03	0.06	0.32	–0.51	–0.06	–0.68	0.22	–0.42
Tula Area	0.15	0.53	0.33	0.83	–0.61	0.72	–0.35	0.21	–0.77	0.40	–0.38
Yaroslavl Area	–0.18	–0.53	0.27	0.68	–0.23	0.41	0.12	0.71	–0.63	0.60	–0.21

Source: own research.

Negative impact of investment in fixed assets and the volume of innovation goods and services may indicate the under investigation of the innovation infrastructure sector in financing inventive activities.

Carrying out the analysis in the context of the subjects of the Central Federal District, we can conclude that the most favourable environment for the inves-

tigation of innovation processes is in the Lipetsk and Orel regions. The cumulative negative impact of factors in the Bryansk, Kursk, Smolensk and Tver regions demonstrates the lack of an institutional basis for the innovation investigation of the regional economy.

Table 3. Results of the correlation analysis of regional innovation systems (based on time series for 2008–2015)

Subject of CFD	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
Belgorod Area	0.65	0.26	–0.22	–0.32	0.11	–0.76	0.77	–0.05	0.18	–0.38	–0.37
Bryansk Area	–0.75	0.67	0.25	0.04	0.22	0.49	–0.12	–0.53	–0.05	–0.38	–0.41
Vladimir-skaya Area	–0.76	–0.52	–0.59	0.71	–0.56	0.57	–0.24	0.63	0.41	0.41	0.52
Voro-nezh-skaya Area	–0.39	–0.67	–0.62	0.49	–0.29	0.44	0.08	0.64	0.17	0.05	0.24
Ivano-vskaya Area	0.67	0.58	0.69	–0.83	–0.59	–0.42	0.33	–0.67	–0.48	0.38	0.65
Kaluga Area	0.22	0.13	0.04	–0.08	–0.64	–0.21	–0.68	0.09	0.31	0.03	0.40
Kostroma Area	–0.40	–0.38	–0.16	–0.36	–0.12	–0.50	–0.58	–0.02	–0.72	–0.17	–0.03
Kursk Area	–0.54	–0.09	–0.60	0.83	–0.26	0.34	–0.61	–0.20	–0.82	0.36	–0.28
Lipetsk Area	–0.60	0.69	0.04	0.74	0.42	0.36	0.32	0.68	0.50	–0.19	–0.33
Orel Area	–0.05	–0.03	0.52	–0.78	0.42	0.82	0.00	0.55	–0.36	0.64	0.60
Ryazan Area	0.08	0.09	–0.15	–0.17	0.59	–0.22	–0.05	–0.12	–0.13	–0.36	0.12
Smolen-skaya Area	–0.64	0.02	–0.64	0.29	–0.16	–0.30	–0.03	0.47	0.22	–0.25	–0.76
Tambov Area	–0.62	0.44	0.29	–0.15	0.40	0.25	–0.28	0.62	0.39	0.24	–0.08
Tverskaya Area	0.49	0.15	–0.17	–0.78	0.51	0.68	–0.39	–0.42	–0.77	–0.02	–0.50
Tula Area	–0.48	0.59	0.20	0.83	–0.74	0.64	–0.08	0.63	–0.86	0.35	–0.13
Yaroslavl Area	–0.04	–0.23	–0.14	0.34	0.34	–0.15	–0.10	0.59	–0.40	0.27	0.40

Source: own research.

2007 can be designated as the beginning of the formation of the national innovation system in Russia, as the President of the Russian Federation approved "The Fundamentals of the Policy of the Russian Federation in the Field of Science and Technology Investigation for the Period Until 2010 and Further Prospects". Therefore, in the hope of improving the research results, a correlation analysis of innovation processes for 2008–2015 was carried out (Table 3).

On the one hand, we can notice an increase in the number of factors positively affecting the innovation investigation of the region's economy. But, on the other hand, the degree of their influence has diminished.

Results of econometric analysis

Table 4 presents the main results of the models of the relationship "the volume of innovation goods and services – an innovation factor" based on time series. We note the statistical significance of all the constructed models. The most innovation regions are Lipetsk, Kaluga and Yaroslavl regions. More often among the factors that cause an increase in the volume of innovation goods and services, there is a "number of personal computers per 100 employees" and "innovation activity".

Table 4. Results of regression analysis of the influence of factors on the volume of innovation goods and services based on time series

Region	Explaining variables	Coefficients	t-statistics	Coefficient elasticity	R^2
Lipetsk Area	α_0	1.232		0.849	0.568
	X_2	152.9	3.438		
	α_0	–1.053		1.129	0.324
	X_3	12.035	2.078		
	α_0	–5.570		1.681	0.733
	X_4	0.463	4.965		
	α_0	–2.426		1.297	0.506
	X_8	0.822	3.034		
Kaluga Area	α_0	0.180		0.955	0.388
	X_8	0.371	2.390		
	α_0	2.621		0.351	0.511
	X_9	0.209	3.066		
	α_0	–0.904		1.224	0.589
	X_{11}	1.030	3.587		
Kursk Area	α_0	–1.921		1.675	0.352
	X_4	0.155	2.211		
Orel Region	α_0	–4.931		2.127	0.335
	X_{11}	1.691	2.128		

Region	Explaining variables	Coefficients	t-statistics	Coefficient elasticity	R^2
Smolenskaya Area	α_0	–0.572		1.242	0.343
	X_4	0.097	2.168		
Tula Area	α_0	–9.364		2.743	0.694
	X_4	0.477	4.521		
	α_0	–3.935		1.732	0.523
	X_6	2.602	3.138		
Yaroslavl Area	α_0	–3.065		1.382	0.468
	X_4	0.314	2.815		
	α_0	–6.544		1.815	0.501
	X_8	1.515	3.005		
	α_0	2.936		0.400	0.362
	X_{10}	1.633	2.262		

Source: own research.

On the basis on the models built, the values of the coefficient of elasticity of the volume of innovation goods and services were calculated from the factors affecting it. Thus, an increase in the proportion of domestic expenditures on research and investigation in the gross regional product by 1% leads to an increase in the volume of innovation goods and services in the Lipetsk region by 0.85%.

Since the results of modeling the investigation of innovation processes in the region on the basis of time series were unsatisfactory, it was decided to conduct a study based on cross-sectional data.

The correlation analysis of the cross series also shows the unformed nature of the innovation systems of the regions (Table 5). Two periods are clearly visible – this is 2006–2007 and 2011–2014. In the first period, the innovation activity of the regions was provided by organizations engaged in research and investigation. In the second period, the push for innovation investigation can be assumed to be the "Strategy of Innovation Investigation of the Russian Federation for the Period to 2020", approved on December 8, 2011, No. 2227-p. The innovation activity of organizations has increased, the process of introducing advanced technologies into production and related technological innovations has begun. In turn, this indicates that the elements of the regional innovation system in this period are more in close functional interdependence.

The results of regression analysis based on cross-sectional data (Table 6) confirm the impact of the above factors.

Among the factors that significantly affect the activity of innovation processes within the regional economies of the Central Federal District, the number of personal computers per 100 employees, the innovation activity of organizations and the proportion of the advanced production technologies of the region in the total number of CFOs are included. In the period of investigation of regional innovation systems (2011–2014), factors of innovation potential of industrial production come into play. However, it should be noted that 2015 is characterized by inhibition of innovation processes in the region.

Table 5. Correlation coefficients of the relationship "factor-the volume of innovation goods and services" based on cross series

Index	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
X_1	–0.42	–0.56	0.23	–0.17	0.15	0.23	0.37	–0.02	0.08	0.12	0.29
X_2	0.15	0.41	0.07	–0.14	–0.25	0.35	–0.01	0.10	0.09	–0.06	–0.12
X_3	0.35	0.46	0.21	0.26	0.24	–0.15	0.24	–0.13	0.02	0.08	–0.12
X_4	–0.35	–0.34	–0.08	0.02	–0.40	0.11	0.20	–0.18	–0.23	–0.27	–0.42
X_5	0.15	0.37	0.28	–0.06	–0.20	0.38	0.07	0.17	0.08	–0.02	0.00
X_6	–0.19	–0.23	–0.15	0.05	0.21	–0.34	0.14	–0.30	–0.24	–0.31	–0.13
X_7	0.29	0.54	0.54	0.26	0.04	0.46	0.00	–0.12	–0.22	–0.09	0.02
X_8	0.22	0.19	0.28	–0.09	–0.16	0.05	0.11	0.60	0.76	0.71	0.40
X_9	–0.15	0.06	–0.21	–0.30	–0.25	0.06	0.14	0.80	0.85	0.44	0.32
X_{10}	–0.04	0.05	0.23	–0.03	0.38	–0.13	0.52	0.72	0.47	0.42	0.21
X_{11}	0.09	0.18	0.32	–0.03	–0.33	–0.07	0.03	–0.06	–0.18	0.03	0.13

Source: own research.

Table 6. Results of regression analysis of the influence of factors on the volume of innovation goods and services based on cross-sectional data

Year	Explainingvariables	Coefficients	t-statistics	Coefficient elasticity	R^2
2006	α_0 X_7	0.215 40.567	2.383	0.942	0.289
2007	α_0 X_7	0.136 47.990	2.426	0.916	0.296
2011	α_0 X_{10}	3.721 0.621	2.273	0.259	0.270
2012	α_0 X_8	–5.714 1.176	2.770	1.911	0.354
	α_0 X_9	–2.393 2.852	4.977	1.381	0.639
	α_0 X_{10}	1.957 2.623	3.891	0.688	0.520
2013	α_0 X_8	–5.242 1.044	4.365	1.997	0.576
	α_0 X_9	–1.617 2.121	6.008	1.308	0.721
	α_0 X_{10}	3.220 1.143	2.010	0.387	0.224
2014	α_0 X_8	–2.560 0.811	3.787	1.453	0.506

Source: own research.

The resulting dynamic series of elasticity coefficients (Fig. 1) shows that a one percent change in the factor in different years leads to approximately the same change in the volume of innovation goods and services.

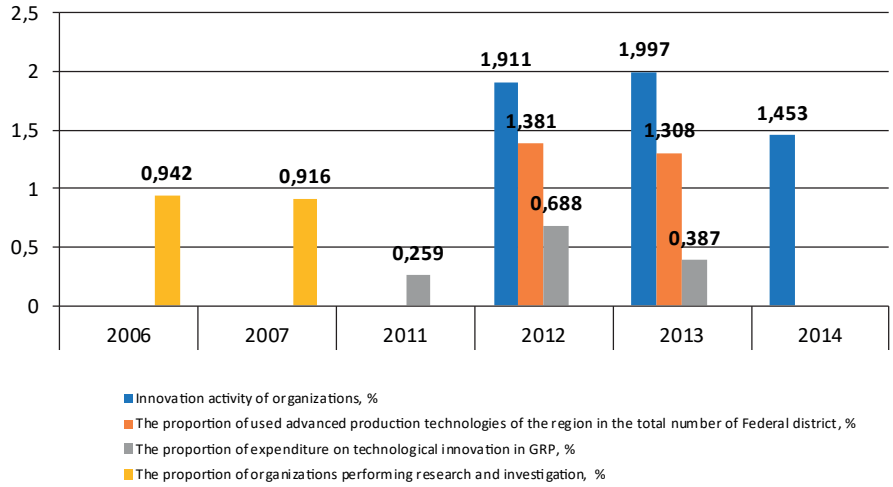

Figure 1. Dynamics of values of the elasticity coefficients of the volume of innovation goods and services from the factors affecting it

Source: own research.

Concluding remarks

The results of the econometric analysis of the innovation systems of the regions of the Central Federal District of Russia in the period 2005–2015 allow us to formulate a number of conclusions:

– at the beginning of 2016, the innovation system in the regions of the CFA is not formed, as its elements are unbalanced and exist "on their own";
– regions with an innovation-oriented economy include Lipetsk, Kaluga and Yaroslavl regions;
– for the establishment of the chain "science-production-market" it is necessary to restore the system of branch research institutes and investigation bureaus that provide the initial stage of the innovation process, consisting in conducting fundamental and applied research, etc.;
– results of the econometric analysis based on time series showed the absence of influence of any factors on the volume of innovation goods and services in the Kostroma region;
– econometric analysis of cross-sectional data has shown that the influence of the region's innovation potential has become noticeable since 2011;
– the proposed algorithm for assessing the impact of factors on RIS and the developed set of models is an integral system of tools for analyzing and evaluating the effectiveness of innovation processes in the region.

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Abstract

The article tries to identify determinants of the regional innovation system and their influence on the volume of innovative goods and services on the basis of econometric analysis for 2005–2015 taking the regional economies of the Central Federal District of Russia as an example. The econometric analysis of cross-sectional data has shown that the influence of the region's innovation potential on the volume of innovative goods and services has become noticeable since 2011. Moreover the regions with an innovation-oriented economy include Lipetsk, Kaluga and Yaroslavl.

Keywords: innovation activity, regional innovation system, determinants of innovations, correlation analysis, regression analysis

JEL classification: C15, O31, P51